IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Atty. Dkt. No: 5333-02800

Inventor(s):
Yasunori Hamai et al

Title: A METHOD FOR DETECTING TRACKING SHORT

CERTIFICATE OF EXPRESS MAIL
UNDER 37 C F R §1 10

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Washington, DC 20231

Shayna Blackmar

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. § 371

INTERNATIONAL APPLICATION NO.: PCT/JP00/06669
INTERNATIONAL FILING DATE: September 27, 2000
PRIORITY DATE CLAIMED: September 29, 1999
U.S. APPLICATION NO. (If known): Unknown

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a FIRST submission of items concerning a filing under 35 U.S.C. § 371.

2. ☐ This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. § 371.

3. ☐ This is an express request to begin national examination procedures (35 U.S.C. § 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. § 371(b) and PCT Articles 22 and 39(l).

4. ☒ A translation of the International Application into English (35 U.S.C. § 371(c)(2)), including: a title page; 14 page specification; 2 page(s) of claims (claims 1-5); 1 page abstract.

5. ☒ Drawings
   ☒ Formal Figure(s) 1-6 on 6 sheet(s).

6. ☒ A copy of the International Application as filed (35 U.S.C. § 371(c)(2))
   ☐ is transmitted herewith (pages).
   ☒ has been transmitted by the International Bureau.
   ☒ A copy of Form PCT/IB/308 (1 page) is enclosed.
   ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).

7. ☐ A copy of the International Publication, Publication No. WO .

8. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. § 371(c)(3))
   - ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   - ☐ have been transmitted by the International Bureau.
   - ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   - ☐ have not been made and will not be made.

9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. § 371(c)(3)).

10. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
   - ☐ A copy of the Demand for International Preliminary Examination is enclosed.

11. ☒ An oath or declaration of the inventor(s) (35 U.S.C. § 371(c)(4)):
   - ☐ is enclosed (_____ pages).
   - ☐ a combined Declaration and Power of Attorney is enclosed (_____ pages).
   - ☒ is not enclosed. Applicant requests the Patent and Trademark Office to accept this application and accord a serial number and filing date as of the date this application is deposited with the U.S. Postal Service for Express Mail. Further, Applicant requests that the NOTICE OF MISSING PARTS-FILING DATE GRANTED be sent to the undersigned representative of Applicant.

12. ☒ Applicant hereby claims priority to:
   - ☒ International Application No.: PCT/JP00/06669 filed September 27, 2000.
   - ☒ [Japan] application No.: 11/276207 filed September 29, 1999.
   - ☒ A copy of Form PCT/IB/304 (1 page) indicating receipt of the priority document by the International Bureau is enclosed.

13. ☐ A translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. § 371(c)(5)).

14. ☒ The entire disclosure of the International Application referred to above is considered to be part of the accompanying application and is hereby incorporated by reference herein.

15. ☐ Assignment Papers.
   - ☐ An assignment document is enclosed for recording (_____ pages).
   - ☐ Form PTO-1595 Assignment Recordation Cover Sheet (page).

16. ☒ A Preliminary Amendment (6 pages).

17. ☒ A substitute specification for pages 1-14, 17 (15 pages).

18. ☒ A strikethrough version of specification and abstract (18 pages).

19. ☐ Power of Attorney
   - ☐ Is enclosed.
   - ☐ a combined Declaration and Power of Attorney is enclosed.

20. ☐ Information Disclosure Statement (IDS), including:
   - ☐ Form PTO-1449
   - ☐ Reference(s) marked according to Form PTO-1449.

21. ☒ Return Receipt Postcard

22. ☐ Small Entity Status
☐ A small entity statement is enclosed.
☐ Small entity status is proper and is requested.

23. ☐ Copy of International Preliminary Examination Report.
☐ A copy of the International Preliminary Examination Report in _____.
☐ English Translation of the International Preliminary Examination Report.

24. ☒ The following fees are submitted:

BASIC NATIONAL FEE (37 CFR § 1.492 (a) (1)-(5): ☐ Neither international preliminary examination fee nor international search fee paid to USPTO and International Search Report not prepared by the EPO or JPO.....$1040.00 ☒ International preliminary examination fee not paid to USPTO but International Search Report prepared by the EPO or JPO.....$890.00 ☐ International preliminary examination fee not paid to USPTO but international search fee paid to USPTO.....$740.00 ☐ International preliminary examination fee paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4).....$710.00 ☐ International preliminary examination fee paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4).....$100.00				
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Surcharge of $130.00 for furnishing oath or declaration later than ☐ 20 ☐ 30 Months from the earliest claimed priority date (37 C.F.R. § 1.492(e)).				
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	15 - 20 =	0	x $18.00 =	
Independent claims	3 - 3 =	0	x $78.00 =	
MULTIPLE DEPENDENT CLAIM(S)			+ $260.00 =	
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TOTAL NATIONAL FEE:				
Fee for recording the enclosed assignment. The assignment must be accompanied by an appropriate cover sheet. $40.00 per property:				
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☒ A fee authorization in the amount of $890.00 is enclosed.

☐ Please charge my Deposit Account No. 50-1505/5333-02800 in the amount of $890.00 to cover the above fees.

☒ The Commissioner is hereby authorized to charge any other fees which may be required or credit any overpayment to Conley, Rose, & Tayon, P.C., Deposit Account No. 50-1505/5333-02800/EBM.

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Signature

Name Eric B. Meyertons
Registration No. 34,876
Date March 29, 2002

PATENT 5333-02800

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.: Unknown
Filed: Herewith
Inventor(s):
Yasunori Hamai et al

Title: A METHOD FOR DETECTING TRACKING SHORT

Examiner: Unknown
Group/Art Unit: Unknown
Atty. Dkt. No: 5333-02800

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Shayna Blackmar

FEE AUTHORIZATION

U.S. Patent and Trademark Office
Box Patent Application
Washington, D.C. 20231

The Commissioner is hereby authorized to charge the following fees to Conley, Rose & Tayon, P.C. Deposit Account Number 50-1505/5333-02800:

$890.00 – Application Filing Fees

Total Amount: $890.00

Attorney Docket No.: 5333-02800

The Commissioner is also authorized to charge any extension fee or other fees which may be necessary to the same account number. If the above mentioned account is found to have insufficient funds, the Commissioner is authorized to charge Conley, Rose & Tayon, P.C. Deposit Account Number 50-1623/5333-02800.

Respectfully submitted,

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Shayna Blackmar

PRELIMINARY AMENDMENT

Commissioner for Patents
P.O. Box 2327
Arlington, VA 22202

Sir:

Please amend the above-captioned application as follows:

In the Specification:

Please replace pages 1-14 of the specification with pages 1-14 of the enclosed substitute sheets. Applicant has also submitted herewith a strikethrough version of the specification indicating the amendments.

In the Claims:

Listed below are clean copies of the amended claims. Marked-up copies of the amended claims are provided as an attachment to this document.

1. (amended) A method for detecting a tracking short in an electric circuit comprising :
measuring a current value during a predetermined period to obtain a frequency distribution of an absolute value of a variation of the current value;
comparing a rate of the frequency in the predetermined variation range over a total frequency with a reference value;
and judging the tracking short to have occurred when the rate is above the reference value.

2. (amended) A method for detecting a tracking short in an electric circuit comprising:
measuring an absolute value of the current value at each unit time to obtain a current waveform which is used for judgment wherein the unit time is what is obtained by dividing a predetermined period into several divided time units;
calculating a variation of the current value at each unit time comprising getting the difference between an absolute value at each unit time and an absolute value at an adjacent unit time,
and judging tracking short to have occurred when a frequency of the variation in a predetermined range for the predetermined period satisfies a pre-set reference.

3. (amended) A method for detecting a tracking short according to claim 2,
wherein there exist a plurality of said variation ranges, and said reference of frequency is set respectively for each of said plurality of ranges,
and wherein the said step of judging is judging the tracking short to have occurred when each frequency in all the ranges satisfies the corresponding reference.

4. (amended) A method for detecting tracking short according to claim 2, wherein the judgment is performed at every unit time for the predetermined period.

5. (amended) A method for detecting tracking short according to claim 2, further comprising dividing the unit time into several divided time units, obtaining an absolute value of a peak value of current in each said divided time unit, calculating a difference between said value and the previous or next value of it, and initializing and restarting the said judgment when the absolute value of said difference is below the predetermined reference value.

Please add the following claims.

6. A method for detecting tracking short according to claim 3, wherein the judgment is performed at every unit time for the predetermined period.

7. A method for detecting tracking short according to claim 3, further comprising dividing the unit time into several divided time units, obtaining an absolute value of a peak value of current in each said divided time unit, calculating a difference between said value and the previous or next value of it, and initializing and restarting the said judgment when the absolute value of said difference is below the predetermined reference value.

8. A method for detecting tracking short according to claim 4, further comprising dividing the unit time into several divide time units, obtaining an absolute value of a peak value of current in each said divided time unit, calculating a difference between said value and the previous or next value of it, and initializing and restarting the said judgment when the absolute value of said difference is below the predetermined reference value.

9. A method for detecting tracking short according to claim 6,
further comprising dividing the unit time into several divided time units, obtaining an absolute value of a peak value of current in each said divided time unit, calculating a difference between said value and the previous or next value of it, and initializing and restarting the said judgment when the absolute value of said difference is below the predetermined reference value.

10. A method for detecting a tracking short in an electric circuit comprising:
measuring an absolute value of the current value at each unit time to obtain a current waveform which is used for judgment wherein the unit time is what is obtained by dividing a predetermined period into several divided unit times;
calculating a variation of the current value at each unit time;
and judging tracking short to have occurred when a frequency of the variation in a predetermined range for the predetermined period satisfies a pre-set reference;
wherein the judgment is performed at every unit time for the predetermined period.

11. A method for detecting tracking short according to claim 10,
wherein calculating a variation of the current value at each unit time comprises getting the difference between an absolute value at each unit time and an absolute value at an adjacent unit time;

12. A method for detecting a tracking short according to claim 10,
wherein there exist a plurality of said variation ranges, and said reference of frequency is set repectively for each of said plurality of ranges;
and wherein the said step of judging is judging the tracking short to have occurred when each frequency in all the ranges satisfies the corresponding reference

13. A method for detecting tracking short according to claim 10,

further comprising dividing the unit time into several divided time units, obtaining an absolute value of a peak value of current in each said divided time unit, calculating a difference between said value and the previous or next value of it, and initializing and restarting the said judgment when the absolute value of said difference is below the predetermined reference value.

14. A method for detecting a tracking short according to claim 11,
wherein there exist a plurality of said variation ranges, and said reference of frequency is set repectively for each of said plurality of ranges;
and wherein the said step of judging is judging the tracking short to have occurred when each frequency in all the ranges satisfies the corresponding reference

15. A method for detecting tracking short according to claim 11,
further comprising dividing the unit time into several divided time units, obtaining an absolute value of a peak value of current in each said divided time unit, calculating a difference between said value and the previous or next value of it, and initializing and restarting the said judgment when the absolute value of said difference is below the predetermined reference value.

In the Abstract:

Please replace the abstract with the enclosed substitute sheet. Applicant has also submitted herewith a strikethrough version of the abstract indicating the amendments.

It is believed that no fees are due in connection with the filing of this Preliminary Amendment. However, if any fees are due, the Assistant Commissioner is hereby authorized to

deduct said fees from Conley, Rose & Tayon Deposit Account No. 50-1505/5333-02800/EBM.

Respectfully submitted,

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Date: 3/29/02

Substitute Specification

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention generally relates to a method for detecting a tracking short in an electric circuit. More particularly, the invention relates to distinguishing the normal variation of current caused by the use of several electric devices from the tracking short current.

Description of the Relevant Art

A tracking short may occur once a carbonized conductive passage is formed in the isolator positioned between two points of an electric circuit, current may then flow through the formed conductive passage. Then, the carbide in the passage can become over heated causing the carbonization of the isolator around the passage. As this process is repeated, the amount of current flowing between the two points in the electric circuit increases. As the current flow increases, the heat generated can finally cause a fire or burning. Such a phenomenon is called 'tracking short'. Tracking short it likely to occur especially in the outlets or plugs that have not be used for a long time, and once occurring, it is tends to develop into a fire. One conventional method for detecting the occurrence of a short in an electric circuit, is known and includes: detecting a current value in the electric circuit using a current transformer; converting the current value to a voltage value by a current-voltage converter; A/D converting the voltage value by an A/D converter; and judging whether the short has occurred or not. Judging whether the short has occurred or not is performed by: summing up the A/D converted values only for the predetermined period by an integrate circuit; comparing the sum with the predetermined reference value; and outputting the signal indicating the occurrence of a short when the sum exceeds the reference value.

A second conventional method for detecting the occurrence of a short in an electric circuitis by detecting a current value at every unit time and judging whether the short has occurred or not on the basis of the variation of the absolute value of the current value. In this method, for example, when the second current

value is smaller than the first current value and the third current value is bigger than the second current value, the signal indicating the occurrence of a short is produced.

However, according to the first conventional method, as only the current values for the predetermined period are summed up, it is necessary to set the reference value smaller than the summed value to detect a relatively small short current such as in case of tracking short. In case of a general short of two wires getting in touch with each other, the short current flowing between two wires is over several hundreds Ampere. In the contrary, in case of a tracking short, the short current is several Ampere to about several scores Ampere. Therefore, in this conventional method, the reference value has to be below several Ampere to about several scores Ampere to detect the tracking short. However, occasionally several Ampere to about several scores Ampere of sudden over-current could flow in an electric appliance like an incandescent lamp. It is difficult to distinguish such a sudden over-current from an electric appliance from the tracking short current. For example, in an incandescent lamp of 20 Ampere rated current, the sudden over-current could be up to 200 Ampere.

Further, according to the second conventional method, in the case of using several household electric appliances simultaneously, the variation of current value of each appliance is mixed up. When the variation of current value is mixed it could show the same amount of variation that appears in a tracking short. Therefore, it is still difficult to detect the tracking short without error from the current caused by the use of several household electric appliances.

As described above, according to the conventional methods, it is very difficult to detect a tracking short without error. It is because the current caused by a tracking short is almost the same as the current caused by the normal use of electric appliances.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a method for detecting tracking short without error by distinguishing the tracking short current from the current caused by the normal use of electric appliances or electric devices.

The following comparison test was performed. The test was for comparing frequency distribution of current variation caused by a tracking short in a plug with that of a current variation caused by the normal use of several kinds of household electric appliances.

A predetermined period of time was set at about 0.2 sec. A unit of time was obtained by dividing the predetermined period into 7 parts, and a current value obtained at every unit time is the absolute value of the peak value of current in the unit time.

Whenever obtaining the current value, it was compared with a current value obtained at previous unit time and the difference between them recorded as the variation for each unit time. By repetition of the above process, a frequency distribution of variation was determined. The frequency distribution of variation was then compared to the case of a tracking short with the case of the normal use of household electric appliances.

A tracking short was intentionally formed by carbonizing the insulator between tracking electrodes in advance and supplying a AC(100V) power. Then, the waveform of current right after the occurrence of the tracking short was observed.

In addition, the waveform of the current was observed when the power was turned on with the rated voltage of several kinds of household electric appliance.

Fig. 2 and Fig. 6 resulted from the experiments showing the frequency distribution of current variation. In Fig. 2 and Fig. 6, the vertical axis indicates the variation (Ampere) at each unit time, and the horizontal axis indicates the rate (%) of the summed value of frequencies in each variation range over the total sum of frequencies in the predetermined period.

Fig. 2 shows the frequency distribution of current variation in case of the occurrence of a tracking short. Fig. 6 shows the frequency distribution of current variation for the appliance showing the biggest variation among the several kinds of household electric appliance.

In comparison of Fig. 2 with Fig. 6, Fig. 2 shows that the variation is mostly concentrated in the range of 0~4 Ampere, and Fig.6 shows that although it generally spreads broadly, the variation in the range of 5~30 Ampere is a little more than that in other ranges.

The method described herein is achieved on the basis of the result of the above test for the purpose of detecting a tracking short. The described method takes advantage of the fact that the frequency distribution of the current variation in the tracking short shows a characteristic feature.

In an embodiment, a method for detecting tracking short with the current value on the electric circuit may include: measuring the current value during the predetermined period to obtain the frequency distribution of the absolute value of current variation; comparing the rate of the frequencies in a predetermined range over the total frequency with reference value; and judging a tracking short to have occurred when said rate is above the reference value.

In some embodiments, a method may be applied to detect the occurrence of a tracking short. The method may further make it possible to detect the

tracking short without error by taking advantage of the frequency distribution of current variation as a judgment condition.

In certain embodiments, a method may be provided for detecting a tracking short with the current value on an electric circuit. The method may include measuring the absolute current value at each unit time to obtain the current waveform. The current waveform may be use for judging the occurrence of the tracking short. The unit time may be obtained by dividing a predetermined period into several. The method may include calculating the variation of the current value at each unit time by getting the difference between the absolute current value at each unit time and the absolute current value of the previous or next unit time. The method may include judging a tracking short to have occurred when the frequency in the predetermined variation range for the predetermined period satisfies the pre-set reference.

In certain embodiments there may exist a plurality of variation ranges, and a reference of frequency is set for each plurality of ranges. The judgment step may judge the occurrence of a tracking short when each frequency in all the ranges satisfies the corresponding reference.

In some embodiments, a method for detecting a tracking short may include performing a judgment at every unit time during the predetermined period.

In other embodiments, the method may include: dividing the predetermined period into several unit times; performing the judgment step at every unit time; and outputting the result. In addition, the method may include erasing an oldest datum of past predetermined period at every unit time.

In other embodiments, a method may include: dividing the unit time into several; obtaining the absolute value of the peak value of the current in every said divided time; and calculating the difference between each said obtained value and

previous or next value of it. The method may further include initializing and restarting the judgment step when the absolute value of the difference is below the predetermined reference value. An advantage may be providing more errorless method for detecting tracking short. More specifically, it may be possible to protect against error far better by further dividing the unit time into several parts and giving a corresponding judgment condition to each part. The reason being because it is often that the current variation exceeds the reference value only for pretty short time in case of tracking short.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the invention will become apparent upon reading the following detailed description and upon reference to the accompanying drawings.

Fig. 1 is a block diagram illustrating the configuration of the circuit.

Fig. 2 is a graph illustrating the exemplary frequency distribution o current variation in case the tracking short occurs.

Fig. 3 is for explanation of the detecting method.

Fig. 4 is for explanation of the detecting method.

Fig. 5 is for explanation of the detecting method.

Fig. 6 is a graph illustrating the exemplary frequency distribution of current variation in case of the household electric appliance.

While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof are shown by way of example in the drawing and will herein be described in detail. It should be understood, however, that the drawings and detailed description thereto are not intended to limit the invention to the particular form disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the present invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

A method for detecting a tracking short is characterized in detecting current in an electric circuit and judging the occurrence of a tracking short on the basis of the variation of the detected current for a predetermined time.

Referring to Fig. 1, there is shown a block diagram showing the configuration of the circuit of one embodiment in, for example, a circuit breaker. As shown in Fig. 1, the circuit breaker of the embodiment may include current transformer 1, current-voltage converter 2, rectifier circuit 3 and judgment circuit 11.

Current transformer 1 may detect current flowing in electric circuit 10 and outputs AC current.

Current-voltage converter 2 may convert the AC current outputted from current transformer 1 into AC voltage, particularly through a resistor.

Rectifier circuit 2 may rectify the output voltage from current-voltage converter 2 using diodes etc. and output the absolute value of it. By using the absolute value, when an A/D converter digitalizes the voltage, a higher resolution can be obtained than in a case not using the absolute value.

Judgment circuit 11 may be adapted to observe the output voltage from rectifier circuit 3. Judgment circuit 11 may further judge whether the current is corresponding to a tracking short or not. In case a tracking short occurs, judgment circuit 11 may output a cut-off command signal to the cut-off circuit so that a cut-off coil opens the contact of the circuit breaker.

Judgment circuit 11 may include a microcomputer including A/D converter 4, ALU 12, register circuit 13, and judgement output circuit 6.

A/D converter 4 may digitalize the output voltage from rectifier circuit 3 by dividing the voltage into a predetermined time width (sampling time). The predetermined time width may be several milli second or below. For example, the sampling time can be about 0.25 ms.

For example, when the maximum input voltage of A/D converter 4 is 5V, and the resolution of the digitalization is 8 bit, the output of A/D converter 4 is 0 for 0V of input voltage, 127 for 2.5V, and 255 for 5V. By adjusting current-voltage converter 2 so that the current of 1 bit is corresponding to 1A when A/D converting, it may be possible to observe the current waveform of 0A~+255A with A/D converter 4. Further, as the means for digitalization, ALU 12 equipped with A/D converter 4 inside can be used.

ALU 12 may process the current variation numerically on the basis of A/D converted value by A/D converter 4, and outputs the current variation data to register circuit 13. Further, ALU 12 may read out the variation data stored in register circuit 13, an may perform the judgment of the occurrence of a tracking short according to a built-in program. ALU 12 may output the result signal to judgment output circuit 6 in case the tracking short occurs.

Register circuit 13 may retain a plurality of current variations for the recent predetermined period in time by erasing the oldest current variation while simultaneously writing in the latest current variation whenever the new current variation is transmitted from ALU 12. The number of current variations retained in register circuit 13 should be more than 7 for improved accuracy of judgment. The number of current variations retained can be decided according to the capacity of the memory in the microprocessor and the length of judgment time.

In certain embodiments, judgment output circuit 6 may receive the judgment signal from ALU 12 and output a signal to a cut-off circuit.

ALU 12 may extract the peak value of current at every half-wavelength from the data of each sampling time transmitted from A/D convertor 4. In addition, ALU 12 may compare it with the previous peak value, and may transmit the difference of the two values to register circuit 13 as a current variation. Register circuit 13 may store the current variation data of the predetermined period. When receiving the new data from ALU 12, register circuit 13 may erase the oldest data while writing in the latest data. Herein, the predetermined period may be about 0.2 sec.

ALU 12 may transmit the latest data to register circuit 13 and take the current variation data from register circuit 13. In addition, ALU 12 may calculate the frequency distribution of the variation such as shown in Fig. 2 with the variation of the each data, and calculate the sum of frequencies in the predetermined variation range and the total frequency. ALU 12 may also calculate the rate of the sum of frequencies in the predetermined variation range over the total frequency, and judge whether the rate is above the judgment reference or not.

Referring to Fig. 6, there is shown an exemplary frequency distribution of the current variation when household electric appliance are used. It is shown that the frequency of variation is concentrated in the range of 0 ~ 4 A. On the contrary, Fig. 2 is an exemplary frequency distribution of the current variation in case of a tracking short, and it is shown that the most frequency of variation exists in the range of 5 ~ 30A. Therefore, by way of calculating what percentage the frequencies in the variation range of 5 ~ 30A occupies within the chosen range of total frequency and judging whether it exceeds the judgment reference or not, it may be possible to judge exactly whether the flowing current is caused by the use of household electric appliance or by a tracking short even though the magnitude of the flowing currents in both cases are almost same.

Herein, the judgments by ALU 12 may be performed on the basis of the data for the predetermined period. The predetermined period may be about 0.2 sec.

Fig. 3 depicts an explanation of unit time A(i), detected current value IPA(i) at each unit time, current variation ΔIPA(i), and a predetermined period. The predetermined period may be divided into a plurality of unit times A(i)(here, i=1~n, n is a positive number). IPA(i) may be a current value that ALU 12 extracts in the unit time A(i) from the data transferred from A/D convertor 4 in Fig. 1 at every sampling time. Although, in this embodiment, said IPA (i) is a peak value in the unit time A(i), it can be an average value in the unit time A(i). ΔIPA(i) is a variation corresponding to the difference of a current value in the unit time and a current value in the right previous unit time. It can be expressed as the difference of IPA(i) and IPA(i-1).

Referring to Fig. 3, register circuit 13 may retain n data of ΔIPA(1) ~ ΔIPA(n) and a datum of IPA(n). The initial status of said data may be set zero.

A/D convertor 4 may transmit the data at each sampling time to said ALU 12. ALU 12 may extract the peak value IPA(n+1) of current in the unit time A(n+1) while simultaneously reading the previous peak value IPA(n) from register circuit 13.

ALU 12 may calculate the ΔIPA(n+1) by the following equation:

$$\Delta IPA(n+1) = IPA(n+1) - \Delta IPA(n).$$

In addition, ALU 12 may transmit the new value of ΔIPA(n+1) and IPA(n+1) back to register circuit 13, wherein if the ΔIPA(n+1) is negative, making it positive before transmission.

Register circuit 13 may be already retaining n data of ΔIPA(1) ~ ΔIPA(n) and a datum of IPA(n) as shown in Fig. 4 even before receiving the ΔIPA(n+1)

from ALU 12. Therefore, if receiving the new data of ΔIPA(n+1) and IPA(n+1) from ALU 12, register circuit 13 erases the oldest data of ΔIPA(1) and IPA(n) and shifts the value of ΔIPA(2) to ΔIPA(1), ΔIPA(3) to ΔIPA(2)... ΔIPA(n+1) to ΔIPA(n) and IPA(n+1) to IPA(n). ALU 12 may also read out the renewed n data of ΔIPA(1) ~ ΔIPA(n) from register circuit 13. In addition, ALU 12 may calculate the sum of the number of data in the range of 5~30A of ΔIPA(i) as a frequency. ALU 12 may output the judgment signal indicating the occurrence of a tracking short to the judgment output circuit in case the frequency is more than nX0.7. An advantage of this method may be it makes it possible to judge whether the tracking short occurs or not with the simpler judgment procedure of just comparing the sum of data in the predetermined range with the reference. As opposed to method wherein the ALU 12 makes the frequency distribution and calculates the rate.

In some embodiments, in addition to a judgment condition about the number of data of which current variation is in the range of 5 ~ 30A, having another condition that the number of data of which current variation is in the range of 11~30A is above nX0.4, the judgment that the tracking short has occurred is issued when the both of conditions are satisfied. This make it possible to increase the accuracy of distinguishment between the current due to a tracking short and the current due to the use of household electric appliance.

In certain embodiments, the unit time A(i) is further divided into m parts Ta(i,1) ~ Ta(i,m)(m is a positive number). In this embodiment, Ta(i,j) is a corresponding time to the half-wavelength of the frequency of commercial AC power. As a cycle could be 50Hz or 60Hz according to the area, it may be set to a middle value, that is, about 9ms.

In Fig. 5, IPT(i,j) is the peak value of the current in a divided time Ta(i,j), and ΔIPT(i,j) is the value obtained by subtracting IPT(i,j-1) from IPT(i,j). ALU 12 may receive the data from A/D converter 4 at every sampling time and may

extract the peak value of current IPT(i,j) in each divided time. ALU 12 may calculate the ΔIPT(i,j) with the previous peak value IPT(i,j-1) by the following equation.

$$\Delta IPT(i,j) = IPT(i,j) - IPT(i,j-1)$$

Herein, if the ΔIPT(i,j) is negative, it is converted to positive.

At the same time, ALU 12 may calculate ΔIPT(i,j) for each divided time Ta(i,1) ~ Ta(i,m). If the ΔIPT(i,j) is above the predetermined value (for example, it is set 5A in this embodiment), ALU 12 proceeds to calculate the next ΔIPT(i,j). If the next ΔIPT(i,j) does not satisfy the predetermined value, ALU 12 may initialize all the procedure and begin the judgment procedures again from the first stage.

More specifically, if all the values of ΔIPT(i,2) ~ ΔIPT(i,m) in the unit time A(i) are above the predetermined value, ALU 12 continues the procedure of extracting the peak value of the current ΔIPT(i) in the unit time A(i). ALU 12 may obtain the current variation ΔIPT(i) by calculating the difference between ΔIPT(i) and IPT(i-1), and transmitting it to register circuit 13. However, otherwise, all the data in register circuit 13 may be initialized. Therefore, for ALU 12 to judge that the flowing current is caused by a tracking short and output a signal to judgment output circuit 6 in Fig. 6, it may be necessary to satisfy two conditions at the same time. One condition may be that all the values of ΔIPT(i,2) ~ ΔIPT(i,m) illustrated in Fig. 5 are above the predetermined value and the procedure is being continued. The other condition may be that the current variation in each unit time A(1) ~ A(n) satisfies the condition that when a frequency of the variation in a predetermined range for the predetermined period satisfies a pre-set reference or when each frequency in all the ranges satisfies the corresponding reference. In a tracking short, most of the above ΔIPT(i,j) can be sustained above the predetermined value, therefore, it may be possible to judge

more exactly whether the current flowing on a circuit is caused by a tracking short or by a malfunction.

As described above, the present invention is described through the embodiments applying to the circuit breaker configured to breaks the circuit when detecting the occurrence of a tracking short. But, the present invention is not restricted to the circuit breaker, and it can be applied to outlets or it can be configured to alarm using a output signal of the judgement circuit 11.

Industrial applicability

According to the method and system described herein, by taking advantage of the current variation in judgment of the occurrence of a tracking short, it becomes possible to judge exactly whether a tracking short has occurred or not . It is also possible to determine the occurrence of a tracking short even though the currents caused by a tracking short and by normal usage of electric devices are almost the same. In addition, it becomes possible to discriminate a tracking short without error by taking advantage of the characteristic current variation even though there occurs a load current or sudden overcurrent, or a plurality of household electric appliance are in use. Therefore, if the method and/or system described herein is applied to a device connected to the power line for a home or a factory, system/method can be used to assist I preventing a tracking short from causing a fire.

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ABSTRACT

The present invention relates to method for a detecting tracking short. In some embodiments, the method may include detecting current flowing on an electric circuit. In other embodiments, the method may include calculating the
10 frequency distribution of the variation of the current detected in a predetermined period. In an embodiment, the method may include outputting a detecting signal in case the frequency of variations included in the predetermined range satisfies a judgement reference.

BACKGROUND OF THE INVENTION ~~A METHOD FOR DETECTING TRACKING SHORT~~

Field of the Invention~~TECHNICAL FIELD~~

The present invention generally relates to a method for detecting a tracking short in an electric circuit. More particularly, the invention relates to distinguishing the normal variation of current caused by the use of several electric devices from the tracking short current. ~~If once a carbonized conductive passage is formed in the isolator posed between two points of an electric circuit, current begins to flow between them through the above passage. Then, the carbide included in the passage becomes red-hot, and it causes the carbonization of the isolator around the passage. As this is repeated, the amount of current flowing between two points in the electric circuit becomes increasing, and finally it causes fire or burning. Such a phenomenon is so called 'tracking short'. Tracking short it likely to occur especially in the outlets or plugs that haven't be used for a long time, and once occurring, it is tend to be developed to fire.~~

Description of the Relevant Art~~BACKGROUND ARTS~~

A tracking short may occur once a carbonized conductive passage is formed in the isolator positioned between two points of an electric circuit, current may then flow through the formed conductive passage. Then, the carbide in the passage can become over heated causing the carbonization of the isolator around the passage. As this process is repeated, the amount of current flowing between the two points in the electric circuit increases. As the current flow increases, the heat generated can finally cause a fire or burning. Such a phenomenon is called 'tracking short'. Tracking short it likely to occur especially in the outlets or plugs that have not be used for a long time, and once occurring, it is tends to develop into a fire. ~~As a first~~One conventional method for detecting the occurrence of a short in an electric circuit, ~~it~~ is known and includes: ~~that~~ detecting a current value in the electric circuit using a current transformer~~,~~; converting the current value to

a voltage value by a current-voltage converter~~,~~; A/D converting the voltage value by an A/D converter~~,~~; and judging whether the short has occurred or not. Judging whether the short has occurred or not is performed by: summing up the A/D converted values only for the predetermined period by an integrate circuit~~,~~; comparing the sum with the predetermined reference value~~,~~; and outputting the signal indicating the occurrence of a short when the sum exceeds the reference value.

As ~~a~~ second conventional method for detecting the occurrence of a short in an electric circuit~~, it~~ is ~~known that~~by detecting a current value at every unit time and judging whether the short has occurred or not on the ~~base~~ basis of the variation of the absolute value of the current value. In this method, for example, when the second current value is smaller than the first current value and the third current value is bigger than the second current value, the signal indicating the occurrence of a short is ~~outputted~~produced.

However, according to the first conventional method, as only the current values ~~only~~ for the predetermined period are summed up, it is ~~needed~~ necessary to set the reference value smaller than the summed value to detect ~~the~~ a relatively small short current such as in case of tracking short. In case of a general short of two wires getting in touch with each other, the short current flowing between two wires is over several hundreds ~~Ampare~~Ampere. In the contrary, in case of a tracking short, the short current is several ~~Ampare~~Ampere ~~~~ to about several scores ~~Ampare~~Ampere. Therefore, in this conventional method, the reference value has to be below several ~~Ampare~~Ampere to about ~~~~several scores ~~Ampare~~Ampere to detect the tracking short. However, occasionally several ~~Ampare~~Ampere ~~~~ to about several scores ~~Ampare~~Ampere of sudden over-current could flow in ~~the~~ an electric appliance like an incandescent lamp~~,~~. ~~and it~~ It is difficult to distinguish such a sudden over-current from an electric appliance from the tracking short current. For example, in ~~the~~ an incandescent lamp of 20

~~Ampare~~Ampere rated current, the sudden over-current could be up to 200 ~~Ampare~~Ampere ~~in maximum~~.

Further, according to the second conventional method, in the case of using several household electric ~~appliance~~appliances simultaneously, the variation of current value of each appliance is mixed up~~,~~. When the variation of current value is mixed ~~and occasionally~~ it could show the same amount of variation that appears in a tracking short. Therefore, it is still difficult to detect the tracking short without error ~~by distinguishing~~from the current caused by the use of several household electric ~~appliance~~appliances ~~from the tracking short current~~.

As ~~discribed~~described above, according to the conventional methods, it is very difficult to detect ~~the~~ a tracking short without error. It is because the current caused by a tracking short is almost the same ~~with~~ as the current caused by the normal use of electric appliances.

SUMMARY OF THE INVENTION~~DISCLOSURE OF THE INVENTION~~

It is an object of the invention to provide a method for detecting tracking short without error by distinguishing the tracking short current from the current caused by the normal use of electric appliances or electric devices.

The ~~inventors performed the followed~~ following comparison test was performed. The test ~~is~~ was for comparing frequency distribution of current variation caused by a tracking short in ~~the~~ a plug with that of a current variation caused by the normal use of several kinds of household electric appliances.

~~The above~~A predetermined period ~~is~~ of time was set at about 0.2 sec~~,~~. ~~the above~~A unit of time ~~is~~ was obtained by dividing the predetermined period ~~by~~ into 7 parts, and ~~the~~ a ~~above~~ current value obtained at every unit time is the absolute value of the peak value of current in the unit time.

Whenever obtaining the current value, ~~we~~ it was compared ~~it~~ with a current value obtained at previous unit time and ~~wrote down~~ the difference between them recorded as the variation for each unit time. By repetition of the above process, ~~we got~~a frequency distribution of variation was determined~~,~~. ~~and~~ The frequency distribution of variation was then compared to the case of a tracking short with the case of the normal use of household electric appliances.

A ~~We made~~ tracking short was intentionally formed by carbonizing the insulator between tracking electrodes in advance and supplying a AC(100V) power ~~to there~~. Then, ~~we observed~~ the waveform of current right after the occurrence of the tracking short was observed.

In addition, ~~we observed~~ the waveform of the current was observed when the power was turned on with the rated voltage of several kinds of household electric appliance.

~~As a result, we got~~ Fig._2 and Fig._6 resulted from the experiments ~~that~~ showing the frequency distribution of current variation. In Fig._2 and Fig._6, the vertical axis indicates the variation_(~~Ampare~~Ampere) at each unit time, and the horizontal axis indicates the rate_(%) of the summed value of frequencies in each variation range over the total sum of frequencies in the predetermined period.

Fig._2 shows the frequency distribution of current variation in case of the occurrence of a tracking short~~,~~._ ~~and~~ Fig._6 shows the frequency distribution of current variation for the appliance showing the biggest variation among the several kinds of household electric appliance.

In comparison of Fig._2 with Fig._6, Fig._2 shows that the variation is mostly concentrated in the range of 0~4 ~~Ampare~~Ampere, and Fig.6 shows that although it generally spreads broadly, the variation in the range of 5~30 ~~Ampare~~Ampere is a little more than that in other ranges.

The method described herein ~~present invention~~ is achieved on the ~~base~~ basis of the result of the above test for the purpose of detecting a tracking short. ~~And, it~~The described method takes advantage of the fact that the frequency distribution of the current variation in the tracking short shows a characteristic feature.

~~The inventors of the present invention achieved the following invention on the base of the above test.~~

~~According to claim 1, the present invention is provided with~~In an embodiment, a method for detecting tracking short with the current value on the electric circuit ~~comprising the steps of~~may include: measuring the current value during the predetermined period to obtain the frequency distribution of the absolute value of current variation;~~,~~ comparing the rate of the frequencies in a

predetermined range over the total frequency with reference value;~~,~~ and judging a tracking short to have occurred when said rate is above the reference value.

~~The invention according to claim 1 is~~In some embodiments, a method may be applied to detect the occurrence of a tracking short~~,~~. ~~and~~ The method may further makes it possible to detect ~~it~~ the tracking short without error by ~~the new method~~ taking advantage of the frequency distribution of current variation as a ~~judgement~~judgment condition.

~~According to claim 2, the present invention is~~In certain embodiments, a method may be provided ~~with a method~~ for detecting a tracking short with the current value on an electric circuit. ~~comprising the steps of~~The method may include measuring the absolute current value at each unit time to obtain the current waveform. The current waveform may be use for judging the occurrence of the tracking short. ~~which is used for judgement wherein t~~The unit time ~~is what is~~may be obtained by dividing ~~the~~ a predetermined period into several~~,~~. The method may include calculating the variation of the current value at each unit time by getting the difference between the absolute current value at each unit time and the absolute current value ~~that at right~~of the previous or next unit time~~,~~. ~~and~~ The method may include judging a tracking short to have occurred when the frequency in the predetermined variation range for the predetermined period satisfies the pre-set reference.

~~The invention according to claim 2 provides more specific configuration of the invention according to claim 1.~~

~~According to claim 3, the present invention is provided with a method for detecting tracking short according to claim 2 wherein~~ In certain embodiments there may exists a plurality of variation ranges, and ~~said~~ a reference of frequency is set for ~~the~~ each ~~of said~~ plurality of ranges~~,~~. ~~wherein the~~ The ~~said~~

judgementjudgment step is may configured to judge the occurrence of a tracking short when each frequency in all the ranges satisfies the corresponding reference.

The invention according to claim 3 is another specific configuration of the invention according to claim 2 for more accurate judgement with more judgement conditions.

In some embodiments, According to claim 4, the present invention is provided with a method for detecting a tracking short according to claim 2 or 3 may include performing a wherein said judgementjudgment is performed at every unit time during the predetermined period.

The invention according to claim 4 makes it possible to output a result as soon as the tracking short occurs byIn other embodiments, the method may include: dividing the predetermined period into several unit times;, performing the judgment step at every unit time;, and outputting the result. at relatively small capacity byIn addition, the method may include erasing an oldest datum of past predetermined period at every unit time.

According to claim 5, the present invention is provided with a method for detecting tracking short according to claim 2, 3 or 4, further comprising the steps ofIn other embodiments, a method may include: dividing the unit time into several,-; obtaining the absolute value of the peak value of the current in every said divided time,-; and calculating the difference between each said obtained value and previous or next value of it, and. The method may further include initializing and restarting saidthe judgementjudgment step when the absolute value of the difference is below the predetermined reference value.

The invention according to claim 5An advantage may be is providing more errorless method for detecting tracking short. More specifically, it is may be possible to protects the against error much far better by further dividing the

unit time into several parts and giving a corresponding ~~judgement~~judgment condition to each part~~,~~. The reason being because it is often that the current variation exceeds the reference value only for pretty short time in case of tracking short.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the invention will become apparent upon reading the following detailed description and upon reference to the accompanying drawings.

Fig. 1 is a block diagram illustrating the configuration of the circuit ~~according to the present invention~~.

Fig. 2 is a graph illustrating the exemplary frequency distribution o current variation in case the tracking short occurs.

Fig. 3 is for explanation of the detecting method ~~by the present invention according to claim 2~~.

Fig. 4 is for explanation of the detecting method ~~by the present invention according to claim 4~~.

Fig. 5 is for explanation of the detecting method ~~by the present invention according to claim 5~~.

Fig. 6 is a graph illustrating the exemplary frequency distribution of current variation in case of the household electric appliance.

While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof are shown by way of example in the drawing and will herein be described in detail. It should be understood, however, that the drawings and detailed description thereto are not intended to limit the invention to the particular form disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the present invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION~~DESCRIPTION OF THE PREFERRED EMBODIMENTS~~

A method for detecting a tracking short ~~according to the present invention~~ is characterized in detecting current in an electric circuit and judging the occurrence of a tracking short on the ~~base~~ basis of the variation of the detected current for ~~the~~ a predetermined time.

~~This invention will be described in further detail by way of example with reference to the accompanying drawings.~~

Referring to Fig. 1, there is shown a block diagram showing the configuration of the circuit of one ~~preferred~~ embodiment in, ~~ease of applying the detecting method of the invention to~~ for example, a circuit breaker. As shown in Fig. 1, the circuit breaker of the embodiment ~~is including~~may include ~~a~~ current transformer 1, ~~a~~ current-voltage converter 2, ~~a~~ rectifier circuit 3 and ~~a~~ ~~judgement~~judgment circuit 11.

~~Said c~~Current transformer 1 may detects current flowing in ~~an~~ electric circuit 10 and outputs AC current.

~~Said c~~Current-voltage converter 2 may converts the AC current outputted from ~~said~~ current transformer 1 into ~~the~~ AC voltage, particularly through a resistor.

~~Said r~~Rectifier circuit 2 may rectify~~ies~~ the output voltage from ~~said~~ current-voltage converter 2 using diodes etc. and outputs the absolute value of it. By using the absolute value, when an A/D ~~convertor~~converter ~~digitalizing~~ digitalizes the voltage, ~~the~~ a higher resolution can be obtained than ~~that~~ in a case not using the absolute value.

~~Said judgement~~Judgment circuit 11 ~~is configured~~may be adapted to ~~always~~ observe the output voltage from ~~said~~ rectifier circuit 3. Judgment circuit 11 may further~~,~~ judge whether the current is corresponding to a tracking short or not~~., and, i~~ In case a tracking short occurs, judgment circuit 11 may output a cut-off command signal to the cut-off circuit so that a cut-off coil opens the contact of the circuit breaker.

~~Said judgement~~Judgment circuit 11 ~~is comprising~~may include a microcomputer including ~~the~~ A/D converter 4, ~~a~~ ALU 12, ~~a~~ register circuit 13, and ~~a~~ judgement output circuit 6.

~~Said~~ A/D converter 4 may digitalizes the output voltage from ~~said~~ rectifier circuit 3 by dividing the voltage into ~~the~~ a predetermined time width (sampling time). ~~of~~ The predetermined time width may be ~~the~~ several milli second or below. For example, the sampling time can be about 0.25 ms.

For example, when the maximum input voltage of ~~the~~ A/D converter 4 is 5V, and the resolution of the digitalization is 8 bit, the output of ~~the~~ A/D converter 4 is 0 for 0V of input voltage, 127 for 2.5V, and 255 for 5V. ~~Here, if~~ By adjusting ~~the~~ current-voltage converter 2 so that the current of 1 bit is corresponding to 1A when A/D converting, it ~~is~~ may be possible to observe the current waveform of 0A~+255A with ~~said~~ A/D converter 4. Further, as the means for digitalization, ~~said~~ ALU 12 equipped with ~~said~~ A/D converter 4 inside can be used.

~~Said~~ ALU 12 may processes the current variation numerically on the ~~base~~ basis of A/D converted value by ~~said~~ A/D converter 4, and outputs the current variation data to ~~said~~ register circuit 13. Further, ALU 12~~it~~ may reads out the variation data stored in ~~said~~ register circuit 13, an may performs the ~~judgement~~judgment of the occurrence of a tracking short according to a built-in

program~~,~~. ~~and~~ ALU 12 may outputs the result signal to ~~said judgement~~judgment output circuit 6 in case the tracking short occurs.

~~Said r~~Register circuit 13 ~~is always~~may retain~~ing~~ a plurality of current variations for the recent predetermined period in time ~~order~~ by erasing the oldest current variation while simultaneously writing in the latest current variation whenever the new current variation is transmitted from ~~said~~ ALU 12. ~~It is preferred that the~~ The number of ~~the~~ current variations ~~always~~ retained in ~~said~~ register circuit 13 ~~is~~ should be ~~for example~~ more than 7 for ~~the~~ improved accuracy of ~~judgement~~judgment. ~~Also,~~ The number of current variations retained ~~It~~ can be decided according to the capacity of the memory in the microprocessor and the length of ~~judgement~~judgment time.

In certain embodiments, ~~Said judgement~~judgment output circuit 6 may receives the ~~judgement~~judgment signal from ~~said~~ ALU 12 and outputs a signal to ~~said~~ a cut-off circuit.

~~Said ALU 12 performs the following operations to carry out the method for detecting tracking short according to claim 1.~~

~~Said~~ ALU 12 may extracts the peak value of current at every half-wavelength from the data of each sampling time transmitted from ~~said~~ A/D convertor 4~~,~~. In addition, ALU 12 may compares it with the ~~right~~ previous peak value, and may transmits the difference of the two values ~~them~~ to ~~said~~ register circuit 13 as a current variation. ~~Then, Said r~~Register circuit 13 may stores the current variation data of the predetermined period~~, and,~~ ~~when~~ When receiving the new data from ~~said~~ ALU 12, register circuit 13 may erases the oldest data ~~with~~ while writing in the latest data. Herein, the predetermined period ~~is preferred to~~may be about 0.2 sec.

~~Said~~ ALU 12 may transmits the latest data to ~~said~~ register circuit 13 and takes the current variation data from ~~said~~ register circuit 13. ~~And then, it~~In addition, ALU 12 may calculates the frequency distribution of the variation such as shown in Fig. 2 with the variation of the each data, and calculates the sum of frequencies in the predetermined variation range and the total frequency. ~~After that, it~~ALU 12 may also calculates the rate of the sum of frequencies in the predetermined variation range over the total frequency, and judges whether the rate is above the ~~judgement~~judgment reference or not.

Referring to Fig. 6, there is shown ~~a~~an exemplary frequency distribution of the current variation ~~in case of using~~when household electric appliance are used. It is shown that the frequency of variation is concentrated in the range of 0 ~ 4 A. On the contrary, Fig. 2 is an exemplary frequency distribution of the current variation in case of a tracking short, and it is shown that the most frequency of variation ~~is existed~~exists in the range of 5 ~ 30A. Therefore, by way of calculating what percentage the frequencies in the variation range of 5 ~ 30A occupies ~~about~~ within the chosen range of ~~the~~ total frequency and judging whether it exceeds the ~~judgement~~judgment reference or not, it ~~is~~ may be possible to judge exactly whether the flowing current is caused by the use of household electric appliance or by a tracking short even though the magnitude of the flowing currents in both cases are almost same.

~~Said ALU 12 performs the following operations to carry out the method for detecting tracking short according to claim 2.~~ Herein, the ~~judgements~~judgments by ~~said~~ ALU 12 ~~is~~ may be performed on the ~~base~~ basis of the data for the predetermined period~~, and~~. ~~the~~ The predetermined period ~~is~~ may be about 0.2 sec.

Fig. 3 ~~is for~~depicts an explanation of unit time A(i), detected current value IPA(i) at each unit time, current variation ΔIPA(i), and a predetermined period ~~according to claim 2~~. The predetermined period ~~is~~ may be divided into a plurality

of unit times A(i)(here, i=1~n, n is a positive number). IPA(i) ~~is~~ may be a current value that ~~said~~ ALU 12 extracts in the unit time A(i) from the data transferred from ~~said~~ A/D convertor 4 in Fig. 1 at every sampling time. Although, in this embodiment, said IPA (i) is a peak value in the unit time A(i), it can be an average value in the unit time A(i). ΔIPA(i) is a variation corresponding to the difference of a current value in the unit time and a current value in the right previous unit time. ~~Namely, i~~It can be expressed as the difference of IPA(i) and IPA(i-1).

Referring to Fig. 3, ~~said~~ register circuit 13 ~~is~~ may retain~~ing~~ n data of ΔIPA(1) ~ ΔIPA(n) and a datum of IPA(n). The initial status of said data ~~is~~ may be set zero.

~~Then, said~~ A/D convertor 4 may transmit~~s~~ the data at each sampling time to said ALU 12. ~~Said~~ ALU 12 may extract~~s~~ the peak value IPA(n+1) of current in the unit time A(n+1) ~~with~~ while simultaneously reading ~~out~~ the previous peak value IPA(n) from ~~said~~ register circuit 13.

~~Then, said~~ ALU 12 may calculate~~s~~ the ΔIPA(n+1) by the following equation:~~.~~

ΔIPA(n+1)= IPA(n+1)- ΔIPA(n).

~~And then, it~~In addition, ALU 12 may transmit~~s~~ the new value of ΔIPA(n+1) and IPA(n+1) back to ~~said~~ register circuit 13, wherein if the ΔIPA(n+1) is negative, making it positive before transmission.

~~Said r~~Register circuit 13 ~~is~~ may be already retaining n data of ΔIPA(1) ~ ΔIPA(n) and a datum of IPA(n) as shown in Fig. 4 even before receiving the ΔIPA(n+1) from ~~said~~ ALU 12. Therefore, if receiving the new data of ΔIPA(n+1) and IPA(n+1) from ~~said~~ ALU 12, ~~said~~ register circuit 13 erases the oldest data of ΔIPA(1) and IPA(n) and shifts the value of ΔIPA(2) to ΔIPA(1), ΔIPA(3) to ΔIPA(2)… ΔIPA(n+1) to ΔIPA(n) and IPA(n+1) to IPA(n). ~~At the same time,~~

~~said~~ ALU 12 may also reads out the renewed n data of ΔIPA(1) ~ ΔIPA(n) from ~~said~~ register circuit 13~~,~~. In addition, ALU 12 may calculates the sum of the number of data in the range of 5~30A of ΔIPA(i) as a frequency~~, and~~. ALU 12 may outputs the ~~judgement~~judgment signal indicating the occurrence of a tracking short to ~~said~~the ~~judgement~~judgment output circuit in case the frequency is more than nX0.7.

~~According to above method of claim 2,~~An advantage of this method may be it makes it possible to judge whether the tracking short occurs or not with the ~~much more~~ simpler ~~judgement~~judgment procedure of just comparing the sum of data in the predetermined range with the reference. As opposed to method ~~than the method of claim 1~~ wherein the ALU 12 makes the frequency distribution and calculates the rate.

~~According to claim 3,~~ In some embodiments, in addition to ~~judgement~~a judgment condition about the number of data of which current variation is in the range of 5 ~ 30A, having another condition that the number of data of which current variation is in the range of 11~~—~~30A is above nX0.4, the ~~judgement~~judgment that the tracking short has occurred is issued when the both of conditions are satisfied. This make it possible to increase the accuracy of distinguishment between the current due to a tracking short and the current due to the use of household electric appliance.

~~Fig. 5 is for the explanation of judgement procedure according to claim 5.~~ In certain embodiments, ~~Therein,~~ the unit time A(i) is further divided into m parts Ta(i,1) ~ Ta(i,m)(m is a positive number). In this embodiment, Ta(i,j) is a corresponding time to the half-wavelength of the frequency of commercial AC power. As a cycle could be 50Hz or 60Hz according to the area, it ~~is~~ may be set to a middle value, that is, about 9ms.

In Fig. 5, IPT(i,j) is the peak value of the current in a divided time Ta(i,j), and ΔIPT(i,j) is the value obtained by subtracting IPT(i,j-1) from IPT(i,j). ~~Said~~ ALU 12 may ~~receiving~~ receive the data from ~~said~~ A/D converter 4 at every sampling time and may~~,~~ extracts the peak value of current IPT(i,j) in each divided time. ~~and~~ ALU 12 may calculates the ΔIPT(i,j) with the previous peak value IPT(i,j-1) by the following equation.

ΔIPT(i,j)= IPT(i,j)- IPT(i,j-1)

Herein, if the ΔIPT(i,j) is negative, it is converted to positive.

At the same time, ~~said~~ ALU 12 may calculates ΔIPT(i,j) for each divided time Ta(i,1) ~ Ta(i,m). ~~And then, if~~ If the ΔIPT(i,j) is above the predetermined value (for example, it is set 5A in this embodiment), ~~said~~ ALU 12 proceeds to calculate the next ΔIPT(i,j). If the next ΔIPT(i,j) does not satisfy the predetermined value, ~~said~~ ALU 12 may initializes all the procedure ~~including the procedure of claim 2 and 3~~ and begins the ~~judgement~~judgment procedures again from the first stage.

More specifically, if all the values of ΔIPT(i,2) ~ ΔIPT(i,m) in the unit time A(i) are above the predetermined value, ~~said~~ ALU 12 continues the procedure of extracting the peak value of the current ΔIPT(i) in the unit time A(i~~),~~). ALU 12 may obtain~~ing~~ the current variation ΔIPT(i) by calculating the difference between ΔIPT(i) and IPT(i-1), and transmitting it to ~~said~~ register circuit 13. However, otherwise, all the data in ~~the~~ register circuit 13 ~~are~~ may be initialized. Therefore, for ~~said~~ ALU 12 to judge that the flowing current is caused by a tracking short and output a signal to ~~the judgement~~judgment output circuit 6 in Fig. 6, it ~~is needed~~may be necessary to satisfy two conditions at the same time. One condition ~~is~~ may be that all the values of ΔIPT(i,2) ~ ΔIPT(i,m) illustrated in Fig. 5 are above the predetermined value and the procedure is being continued~~,~~ ~~and t~~. The other condition may be ~~is~~ that the current variation in each unit time A(1) ~ A(n) satisfies the condition that when a frequency of the variation in a

predetermined range for the predetermined period satisfies a pre-set reference or~~in claim 2 or 3~~ when each frequency in all the ranges satisfies the corresponding reference. In a tracking short, most of the above ΔIPT(i,j) ~~are~~ can be sustained above the predetermined value, therefore, ~~according to claim 5,~~ it ~~is~~ may be possible to judge more exactly whether the current flowing on a circuit is caused by a tracking short or ~~not without~~by a malfunction.

As described above, the present invention is described through the embodiments applying to the circuit breaker configured to breaks the circuit when detecting the occurrence of a tracking short. But, the present invention is not restricted to the circuit breaker, and it can be applied to outlets or it can be configured to alarm using a output signal of the judgement circuit 11.

Industrial applicability

~~As above, according to the present invention~~According to the method and system described herein, by taking advantage of the current variation in ~~judgement~~judgment of the occurrence of a tracking short, it becomes possible to judge exactly whether a tracking short has occurred or not ~~in short time,~~. It is also possible to determine the occurrence of a tracking short even though the currents caused by a tracking short and by normal usage of electric devices are almost the same. In addition, it becomes possible to discriminate a tracking short without error by taking advantage of the characteristic current variation even though there occurs a load current or sudden overcurrent, or a plurality of household electric appliance are in use. Therefore, if the ~~present invention applied~~method and/or system described herein is applied to ~~the~~ a device connected to the power line for a home or a factory, ~~it~~ system/method can be used to assist I prevent~~ed~~ing ~~for~~ a tracking short ~~to~~ from ~~cause~~ causing a fire.

ABSTRACT

The present invention relates to method for a detecting tracking short.~~,~~ ~~wherein~~ In some embodiments, the method may include detecting current flowing on an electric circuit.~~,~~ In other embodiments, the method may include calculating the frequency distribution of the variation of the current detected in ~~the~~ a predetermined period.~~,~~ ~~and~~ In an embodiment, the method may include outputting ~~the~~ a detecting signal in case the frequency of variations included in the predetermined range satisfies ~~the~~ a judgement reference.

Strikethrough Version of Amended Claims

WHAT IS CLAIMED IS;

1. A method for detecting a tracking short ~~using a current value~~ in an electric circuit ~~comprises~~ comprising ~~the steps of;~~:

measuring ~~the~~ a current value during ~~the~~ a predetermined period to obtain a frequency distribution of ~~the~~ an absolute value of ~~the~~ a variation of the current value~~,~~;

comparing ~~the~~ a rate of the frequency in the predetermined variation range over ~~the~~ a total frequency with ~~the~~ a reference value~~,~~;

and judging the tracking short to have occurred when ~~said~~ the rate is above ~~said~~ the reference value.

2. A method for detecting a tracking short ~~using a current value~~ in an electric circuit comprise~~s the steps of~~;ing:

measuring ~~the~~ an absolute value of the current value at each unit time to obtain a current waveform which is used for judgment wherein the unit time is what is obtained by dividing ~~the~~ a predetermined period into several divided time units;~~,~~

calculating ~~the~~ a variation of the current value at each unit time ~~by~~ comprising getting the difference between ~~the~~ an absolute value at each unit time and an absolute value at an adjacent ~~that at right previous or next~~ unit time,

and judging tracking short to have occurred when ~~the~~ a frequency of the variation in ~~the~~ a predetermined range for the predetermined period satisfies ~~the~~ a pre-set reference.

3. A method for detecting a tracking short according to claim 2,

wherein there exist a plurality of said variation ranges, and said reference of frequency is set respectively for each of said plurality of ranges,

and wherein the said step of judging is judging the tracking short to have occurred when each frequency in all the ranges satisfies the corresponding reference.

4. A method for detecting tracking short according to claim 2 ~~or 3~~,

wherein ~~said~~the ~~judgement~~judgment is performed at every unit time for the predetermined period.

5. A method for detecting tracking short according to claim 2, ~~3 or 4,~~

further comprising dividing the unit time into several divided time units, obtaining ~~the~~ an absolute value of a peak value of current in each said divided time unit, calculating ~~the~~ a difference between said value and the previous or next value of it, and initializing and restarting the said ~~judgement~~judgment ~~step~~ when the absolute value of said difference is below the predetermined reference value.

PATENT
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A METHOD FOR DETECTING TRACKING SHORT

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6/prts

A METHOD FOR DETECTING TRACKING SHORT

TECHNICAL FIELD

The present invention relates to a method for detecting tracking short in electric circuit. If once a carbonized conductive passage is formed in the isolator posed between two points of an electric circuit, current begins to flow between them through the above passage. Then, the carbide included in the passage becomes red-hot, and it causes the carbonization of the isolator around the passage. As this is repeated, the amount of current flowing between two points in the electric circuit becomes increasing, and finally it causes fire or burning. Such a phenomenon is so called 'tracking short'. Tracking short is likely to occur especially in the outlets or plugs that haven't be used for a long time, and once occurring, it is tend to be developed to fire.

BACKGROUND ARTS

As a first conventional method for detecting the occurrence of short in an electric circuit, it is known that detecting a current value in the electric circuit using a current transformer, converting the current value to a voltage value by a current-voltage converter, A/D converting the voltage value by an A/D converter, and judging whether the short has occurred or not on the base of the A/D converted value. In this method, the judgement whether the short has occurred or not is performed by summing up the A/D converted values only for the predetermined period by a integrate circuit, comparing the sum with the predetermined reference value, and outputting the signal indicating the occurrence of short when the sum exceeds the reference value.

As a second conventional method for detecting the occurrence of short in an electric circuit, it is known that detecting a current value at every unit time and judging whether the short has occurred or not on the base of the variation of the absolute value of the current value. In this method, for example, when the second current value is smaller than the first current value and the third current value is

bigger than the second current value, the signal indicating the occurrence of short is outputted.

However, according to the first conventional method, as the current values only for the predetermined period are summed up, it is needed to set the reference value smaller than the summed value to detect the relatively small short current such as in case of tracking short. In case of general short of two wires getting in touch with each other, the short current flowing between two wires is over several hundreds Ampare. In the contrary, in case of tracking short, the short current is several Ampare ~ several scores Ampare. Therefore, in this conventional method, the reference value has to be below several Ampare ~ several scores Ampare to detect the tracking short. However, occasionally several Ampare ~ several scores Ampare of sudden over-current could flow in the electric appliance like incandescent lamps, and it is difficult to distinguish such a sudden over-current from the tracking short current. For example, in the incandescent lamp of 20 Ampare rated current, the sudden over-current could be 200 Ampare in maximum.

Further, according to the second conventional method, in case of using several household electric appliance simultaneously, the variation of current value of each appliance is mixed up, and occasionally it could show the same amount of variation that appears in tracking short. Therefore, it is still difficult to detect the tracking short without error by distinguishing the current caused by the use of several household electric appliance from the tracking short current.

As discribed above, according to the conventional methods, it is very difficult to detect the tracking short without error. It is because the current caused by tracking short is almost same with the current caused by the normal use of electric appliance.

DISCLOSURE OF THE INVENTION

It is an object of the present invention to provide a method for detecting tracking short without error by distinguishing the tracking short current from the current caused by the normal use of electric appliance.

The inventors performed the followed comparison test. The test is for comparing frequency distribution of current variation caused by tracking short in the plug with that of current variation caused by the normal use of several kinds of household electric appliance.

The above predetermined period is about 0.2 sec, the above unit time is obtained by dividing the predetermined period by 7 parts, and the above current value obtained at every unit time is the absolute value of the peak value of current in the unit time.

Whenever obtaining the current value, we compared it with the current value obtained at previous unit time and wrote down the difference between them as the variation for each unit time. By repetition, we got frequency distribution of variation, and then compared the case of tracking short with the case of the normal use of household electric appliance.

We made tracking short intentionally by carbonizing the insulator between tracking electrodes in advance and supplying a AC(100V) power to there. Then, we observed the waveform of current right after the occurrence of tracking short.

In addition, we observed the waveform of the current when the power was turned on with the rated voltage of several kinds of household electric appliance.

As a result, we got Fig.2 and Fig.6 that show the frequency distribution of current variation. In Fig.2 and Fig.6, the vertical axis indicates the variation(Ampare) at each unit time, and the horizontal axis indicates the rate(%) of the summed value of frequencies in each variation range over the total sum of frequencies in the predetermined period.

Fig.2 shows the frequency distribution of current variation in case of the occurrence of tracking short, and Fig.6 shows the frequency distribution of current variation for the appliance showing the biggest variation among the several kinds of household electric appliance.

In comparison of Fig.2 with Fig.6, Fig.2 shows that the variation is mostly concentrated in the range of 0～4 Ampare, and Fig.6 shows that although it generally spreads broadly, the variation in the range of 5～30 Ampare is a little more than that in other ranges.

The present invention is achieved on the base of the result of the above test for the purpose of detecting tracking short. And, it takes advantage of the fact that the frequency distribution of the current variation in tracking short shows a characteristic feature.

The inventors of the present invention achieved the following invention on the base of the above test.

According to claim 1, the present invention is provided with a method for detecting tracking short with the current value on the electric circuit comprising the steps of measuring the current value during the predetermined period to obtain the frequency distribution of the absolute value of current variation, comparing the rate of the frequencies in a predetermined range over the total frequency with the reference value, and judging tracking short to have occurred when said rate is

above the reference value.

The invention according to claim 1 is applied to detect the occurrence of tracking short, and makes it possible to detect it without error by the new method taking advantage of the frequency distribution of current variation as a judgement condition.

According to claim 2, the present invention is provided with a method for detecting tracking short with the current value on an electric circuit comprising the steps of measuring the absolute current value at each unit time to obtain the current waveform which is used for judgement wherein the uint time is what is obtained by dividing the predetermined period into several, calculating the variation of the current value at each unit time by getting the difference between the absolute current value at each unit time and that at right previous or next unit time, and judging tracking short to have occurred when the frequency in the predetermined variation range for the predetermined period satisfies the pre-set reference.

The invention according to claim 2 provides more specific configuration of the invention according to claim 1.

According to claim 3, the present invention is provided with a method for detecting tracking short according to claim 2 wherein there exist a plurality of variation ranges, and said reference of frequency is set for the each of said plurality of ranges, wherein the said judgement step is configured to judge the occurrence of tracking short when each frequency in all the ranges satisfies the corresponding reference.

The invention according to claim 3 is another specific configuration of the invention according to claim 2 for more accurate judgement with more judgement conditions.

According to claim 4, the present invention is provided with a method for detecting tracking short according to claim 2 or 3 wherein said judgement is performed at every unit time during the predetermined period.

The invention according to claim 4 makes it possible to output a result as soon as the tracking short occurs by dividing the predetermined period into several unit times, performing the judgment step at every unit time, and outputting the result at every unit time. Further, it becomes possible to use the data memory means of a relatively small capacity by erasing an oldest datum of past predetermined period at every unit time.

According to claim 5, the present invention is provided with a method for detecting tracking short according to claim 2, 3 or 4, further comprising the steps of dividing the unit time into several, obtaining the absolute value of the peak value of the current in every said divided time, calculating the difference between each said obtained value and previous or next value of it, and initializing and restarting said judgement step when the absolute value of the difference is below the predetermined reference value.

The invention according to claim 5 is providing more errorless method for detecting tracking short. More specifically, it is possible to protects the error much better by further dividing the unit time into several parts and giving a corresponding judgement condition to each part, because it is often that the current variation exceeds the reference value only for pretty short time in case of tracking short.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram illustrating the configuration of the circuit according to the present invention.

Fig. 2 is a graph illustrating the exemplary frequency distribution of current variation in case the tracking short occurs.

Fig. 3 is for explanation of the detecting method by the present invention according to claim 2.

Fig. 4 is for explanation of the detecting method by the present invention according to claim 4.

Fig. 5 is for explanation of the detecting method by the present invention according to claim 5.

Fig. 6 is a graph illustrating the exemplary frequency distribution of current variation in case of the household electric appliance.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A method for detecting tracking short according to the present invention is characterized in detecting current in an electric circuit and judging the occurrence of tracking short on the base of the variation of the detected current for the predetermined time.

This invention will be described in further detail by way of example with reference to the accompanying drawings.

Referring to Fig. 1, there is shown a block diagram showing the configuration of the circuit of one preferred embodiment in case of applying the detecting method of the invention to a circuit breaker. As shown in Fig. 1, the circuit breaker of the embodiment is including a current transformer 1, a current-voltage convertor 2, a rectifier circuit 3 and a judgement circuit 11.

Said current transformer 1 detects current flowing in an electric circuit 10 and outputs AC current.

Said current-voltage convertor 2 converts the AC current outputted from said current transformer 1 into the AC voltage, particularly through a resistor.

Said rectifier circuit 2 rectifies the output voltage from said current-voltage convertor 2 using diodes etc. and outputs the absolute value of it. By using the absolute value, when A/D convertor digitalizing the voltage, the higher resolution can be obtained than that in case not using the absolute value.

Said judgement circuit 11 is configured to always observe the output voltage from said rectifier circuit 3, judge whether the current is corresponding to tracking short or not, and, in case tracking short occurs, output a cut-off command signal to the cut-off circuit so that a cut-off coil opens the contact of the circuit breaker.

Said judgement circuit 11 is comprising a microcomputer including the A/D convertor 4, a ALU 12, a register circuit 13, and a judgement output circuit 6.

Said A/D convertor 4 digitalizes the output voltage from said rectifier circuit 3 by dividing the voltage into the predetermined time width(sampling time) of the several milli second or below. For example, the sampling time can be about 0.25 ms.

For example, when the maximum input voltage of the A/D convertor 4 is 5V, and the resolution of the digitalization is 8bit, the output of the A/D convertor 4 is 0 for 0V of input voltage, 127 for 2.5V, and 255 for 5V. Here, if adjusting the current-voltage convertor 2 so that the current of 1bit is corresponding to 1A when A/D converting, it is possible to observe the current waveform of 0A ~ +255A with said A/D convertor 4. Further, as the means for digitalization, said ALU 12 equipped with said A/D convertor 4 inside can be used.

Said ALU 12 processes the current variation numerically on the base of A/D converted value by said A/D convertor 4, and outputs the current variation data to said register circuit 13. Further, it reads out the variation data stored in said register circuit 13, performs the judgement the occurrence of tracking short according to built-in program, and outputs the result signal to said judgement output circuit 6 in case the tracking short occurs.

Said register circuit 13 is always retaining a plurality of current variations for the recent predetermined period in time order by erasing the oldest current variation simultaneously writing in the latest current variation whenever the new current variation is tranmitted from said ALU 12. It is preferred that the number of the current variation always retained in said register circuit 13 is for example more than 7 for the accuracy of judgement. Also, It can be decided according to the capacity of the memory in the microprocessor and the length of judgement time.

Said judgement output circuit 6 receives the judgement signal from said ALU 12 and ouputs a signal to said cut-off circuit.

Said ALU 12 performs the following operations to carry out the method for detecting tracking short according to claim 1.

Said ALU 12 extracts the peak value of current at every half-wavelength from the data of each sampling time transmitted from said A/D convertor 4, compares it with the right previous peak value, and transmits the difference of them to said register circuit 13 as a current variation. Then, Said register circuit 13 stores the current variation data of the predetermined period, and, when receiving the new data from said ALU 12, erases the oldest data with writing in the latest data. Herein, the predetermined period is preferred to be about 0.2 sec.

Said ALU 12 transmits the latest data to said register circuit 13 and takes the current variation data from said register circuit 13. And then, it calculates the frequency distribution of the variation such as shown in Fig. 2 with the variation of the each data, and calculates the sum of frequencies in the predetermined variation range and the total frequency. After that, it calculates the rate of the sum of frequencies in the predetermined variation range over the total frequency, and judges whether the rate is above the judgement reference or not.

Referring to Fig. 6, there is shown a exemplary frequency distribution of the current variation in case of using household electric appliance. It is shown that the frequency of variation is concentrated in the range of 0 ~ 4 A. On the contrary, Fig. 2 is a exemplary frequency distribution of the current variation in case of tracking short, and it is shown that the most frequency of variation is existed in the range of 5 ~ 30A. Therefore, by way of calculating what percentage the frequencies in the variation range of 5 ~ 30A occupies about the total frequency and judging whether it exceeds the judgement reference or not, it is possible to judge exactly whether the flowing current is caused by the use of household electric appliance or by tracking short even though the magnitude of the flowing currents in both cases are almost same.

Said ALU 12 performs the following operations to carry out the method for detecting tracking short according to claim 2. Herein, the judgement by said ALU 12 is performed on the base of the data for the predetermined period, and the

predetermined period is about 0.2 sec.

Fig. 3 is for the explanation of unit time A(i), detected current value IPA(i) at each unit time, current variation ΔIPA(i), and predetermined period according to claim 2. The predetermined period is divided into a plurality of unit times A(i)(here, i=1~n, n is a positive number). IPA(i) is a current value that said ALU 12 extracts in the unit time A(i) from the data transferred from said A/D convertor 4 in Fig. 1 at every sampling time. Although, in this embodiment, said IPA(i) is a peak value in the unit time A(i), it can be a average value in the unit time A(i). Δ IPA(i) is a variation corresponding to the difference of a current value in the unit time and a current value in the right previous unit time. Namely, it can be expressed as the difference of IPA(i) and IPA(i-1).

Referring to Fig. 3, said register circuit 13 is retaining n data of ΔIPA(1)~Δ IPA(n) and a datum of IPA(n). The initial status of said data is set zero.

Then, said A/D convertor 4 transmits the data at each sampling time to said ALU 12. Said ALU 12 extracts the peak value IPA(n+1) of current in the unit time A(n+1) with simultaneously reading out the previous peak value IPA(n) from said register circuit 13.

Then, said ALU 12 calculates the ΔIPA(n+1) by the following equation.

ΔIPA(n+1)=IPA(n+1)-ΔIPA(n)

And then, it transmits the new value of ΔIPA(n+1) and IPA(n+1) back to said register circuit 13, wherein if the ΔIPA(n+1) is negative, making it positive before transmission.

Said register circuit 13 is already retaining n data of ΔIPA(1)~ΔIPA(n) and a datum of IPA(n) as shown in Fig. 4 even before receiving the ΔIPA(n+1) from said ALU 12. Therefore, if receiving the new data of ΔIPA(n+1) and IPA(n+1) from said ALU 12, said register circuit 13 erases the oldest data of ΔIPA(1) and IPA(n) and shifts the value of ΔIPA(2) to ΔIPA(1), ΔIPA(3) to ΔIPA(2)⋯ΔIPA(n+1) to

ΔIPA(n) and IPA(n+1) to IPA(n). At the same time, said ALU 12 reads out the renewed n data of ΔIPA(1) ~ ΔIPA(n) from said register circuit 13, calculates the sum of the number of data in the range of 5 ~ 30A of ΔIPA(i) as a frequency, and outputs the judgement signal indicating the occurrence of tracking short to said judgement output circuit in case the frequency is more than n×0.7.

According to above method of claim 2, it makes possible to judge whether the tracking short occurs or not with the much more simple judgement procedure of just comparing the sum of data in the predtermined range with the reference than the method of claim 1 wherein the ALU 12 makes the frequency distribution and calculates the rate.

According to claim 3, in addition to judgement condition about the number of data of which current variation is in the range of 5 ~ 30A, having another condition that the number of data of which current variation is in the range of 11 ~ 30A is above n×0.4, the judgement that the tracking short has occurred is issued when the both of conditions are satisfied. This make it possible to increase the accuracy of distinguishment between the current due to tracking short and the current due to the use of household electric appliance.

Fig. 5 is for the explanation of judgement procedure according to claim 5. Therein, the unit time A(i) is further divided into m parts Ta(i,1) ~ Ta(i,m)(m is a positive number). In this embodiment, Ta(i,j) is a corresponding time to the half-wavelength of the frequency of commercial AC power. As a cycle could be 50Hz or 60Hz according to the area, it is set a middle value, that is, about 9ms.

In Fig. 5, IPT(i,j) is the peak value of the current in a divided time Ta(i,j), and ΔIPT(i,j) is the value obtained by subtracting IPT(i,j-1) from IPT(i,j). Said ALU 12 receiving the data from said A/D converter 4 at every sampling time, extracts the peak value of current IPT(i,j) in each divided time and calculates the ΔIPT(i,j) with the previous peak value IPT(i,j-1) by the following equation.

$\Delta IPT(i,j)=IPT(i,j)-IPT(i,j-1)$

Herein, if the $\Delta IPA(i,j)$ is negative, it is converted to positive.

At the same time, said ALU 12 calculates $\Delta IPT(i,j)$ for each divided time $Ta(i,1) \sim Ta(i,m)$. And then, if the $\Delta IPT(i,j)$ is above the predetermined value(it is set 5A in this embodiment), said ALU 12 proceeds to calculate the next $\Delta IPT(i,j)$. If the next $\Delta IPT(i,j)$ does not satisfy the predetermined value, said ALU 12 initializes all the procedure including the procedure of claim 2 and 3 and begins the judgement procedure again from the first stage.

More specifically, if all the values of $\Delta IPT(i,2) \sim \Delta IPT(i,m)$ in the unit time A(i) are above the predetermined value, said ALU 12 continues the procedure of extracting the peak value of the current $\Delta IPT(i)$ in the unit time A(i), obtaining the current variation $\Delta IPT(i)$ by calculating the difference between $\Delta IPT(i)$ and IPA(i-1), and transmitting it to said register circuit 13. However, otherwise, all the data in the register circuit 13 are initialized. Therefore, for said ALU 12 to judge that the flowing current is caused by tracking short and output a signal to the judgement output circuit 6 in Fig. 6, it is needed to satisfy two conditions at the same time. One is that all the values of $\Delta IPT(i,2) \sim \Delta IPT(i,m)$ illustrated in Fig. 5 are above the predetermined value and the procedure is being continued, and the other is that the current variation in each unit time $A(1) \sim A(n)$ satisfies the condition in claim 2 or 3. In tracking short, most of above $\Delta IPT(i,j)$ are sustained above the predetermined value, therefore, according to claim 5, it is possible to judge more exactly whether the current flowing on a circuit is caused by tracking short or not without malfunction.

As described above, the present invention is described through the embodiments applying to the circuit breaker configured to breaks the circuit when detecting the occurrence of tracking short. But, the present invention is not restricted to the circuit breaker, and it can be applied to outlets or it can be configured to alarm using a output signal of the judgement circuit 11.

Industrial applicability

As above, according to the present invention, by taking advantage of the current variation in judgement of the occurrence of tracking short, it becomes possible to judge exactly whether tracking shot has occurred or not in short time, even though the currents caused by tracking short and by normal usage of electric device are almost same. In addition, it becomes possible to discriminate tracking short without error taking advantage of the characteristic current variation even though there occurs a load current or sudden overcurrent, or a plurality of household electric appliance are in use. Therefore, if the present invention is applied to the device connected to the power line for home or factory, it can be prevented for tracking short to cause fire.

WHAT IS CLAIMED IS;

1. A method for detecting tracking short using a current value in an electric circuit comprises the steps of;

measuring the current value during the predetermined period to obtain a frequency distribution of the absolute value of the variation of the current value,

comparing the rate of the frequency in the predetermined variation range over the total frequency with the reference value,

and judging tracking short to have occurred when said rate is above said reference value.

2. A method for detecting tracking short using a current value on an electric circuit comprises the steps of;

measuring the absolute value of the current value at each unit time to obtain a current waveform which is used for judgement wherein the unit time is what is obtained by dividing the predetermined period into several,

calculating the variation of the current value at each unit time by getting the difference between the absolute value at each unit time and that at right previous or next unit time,

and judging tracking short to have occurred when the frequency of the variation in the predetermined range for the predetermined period satisfies the pre-set reference.

3. A method for detecting tracking short according to claim 2,

wherein there exist a plurality of said variation ranges, and said reference of frequency is set repectively for each of said plurality of ranges,

and wherein the said step of judging is judging tracking short to have occurred when each frequency in all the ranges satisfies the corresponding reference.

4. A method for detecting tracking short according to claim 2 or 3,

wherein said judgement is performed at every unit time for the predetermined period.

5. A method for detecting tracking short according to claim 2, 3 or 4,

further comprising dividing the unit time into several, obtaining the absolute value of peak value of current in each said divided time, calculating the difference between said value and the previous or next value of it, and initializing and restarting the said judgement step when the absolute value of said difference is below the predetermined reference value.

ABSTRACT

The present invention relates to method for detecting tracking short, wherein detecting current flowing on an electric circuit, calculating the frequency distribution of the variation of the current detected in the predetermined period, and outputting the detecting signal in case the frequency of variation included in the predetermined range satisfies the judgement reference.

FIG. 1

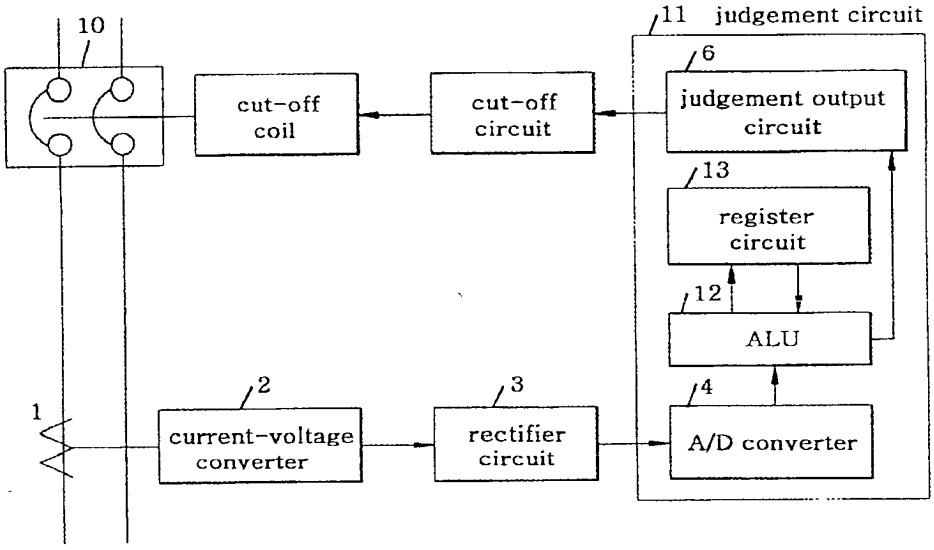

10
11 judgement circuit
6
judgement output circuit
cut-off coil
cut-off circuit
13
register circuit
12
ALU
1
2
current-voltage converter
3
rectifier circuit
4
A/D converter

FIG. 2

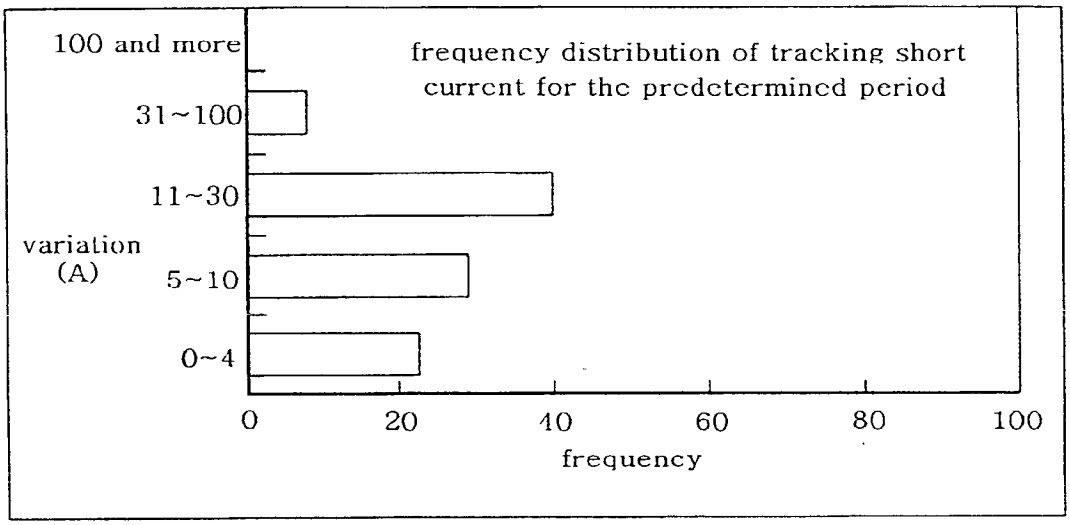

100 and more
31~100
11~30
5~10
0~4
variation
(A)
frequency distribution of tracking short
current for the predetermined period
0
20
40
60
80
100
frequency

FIG. 3

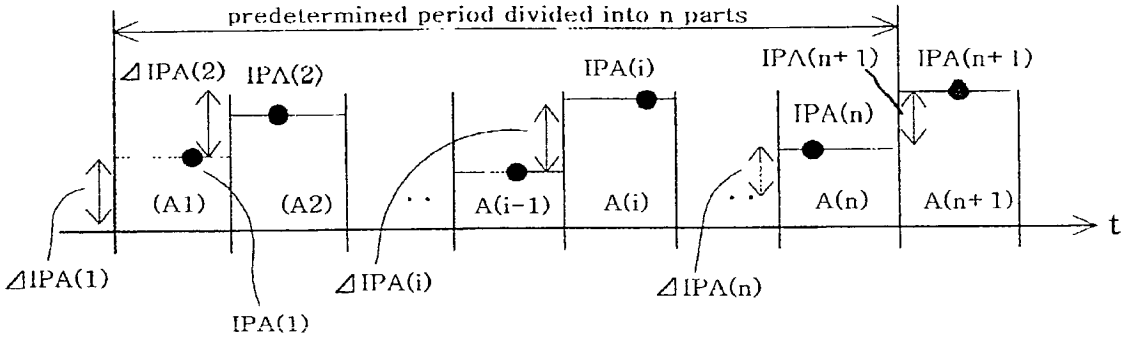

predetermined period divided into n parts
⊿IPA(2)
IPA(2)
IPA(i)
IPA(n+1)
IPA(n+1)
IPA(n)
(A1)
(A2)
A(i-1)
A(i)
A(n)
A(n+1)
t
⊿IPA(1)
IPA(1)
⊿IPA(i)
⊿IPA(n)

FIG. 4

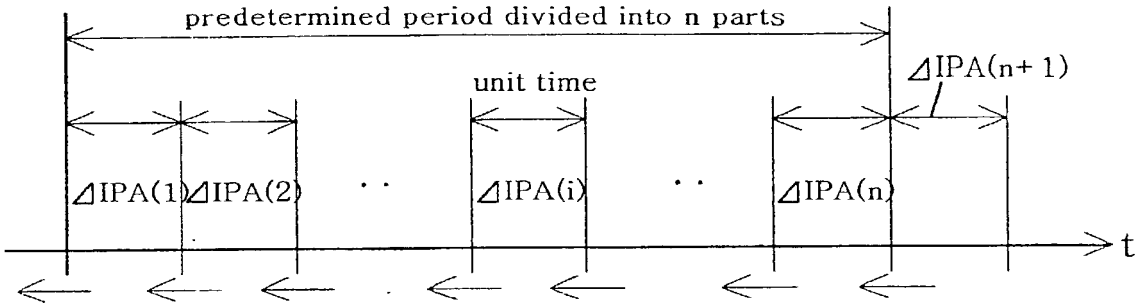

predetermined period divided into n parts
unit time
⊿IPA(n+ 1)
⊿IPA(1)
⊿IPA(2)
⊿IPA(i)
⊿IPA(n)
t

FIG. 5

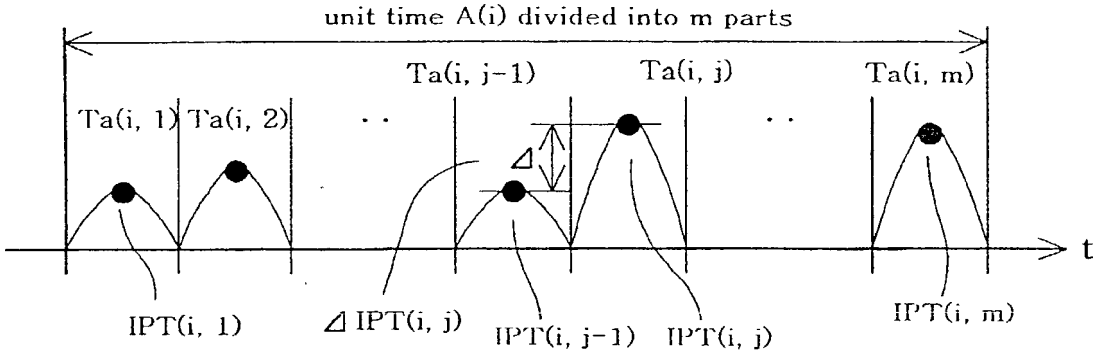
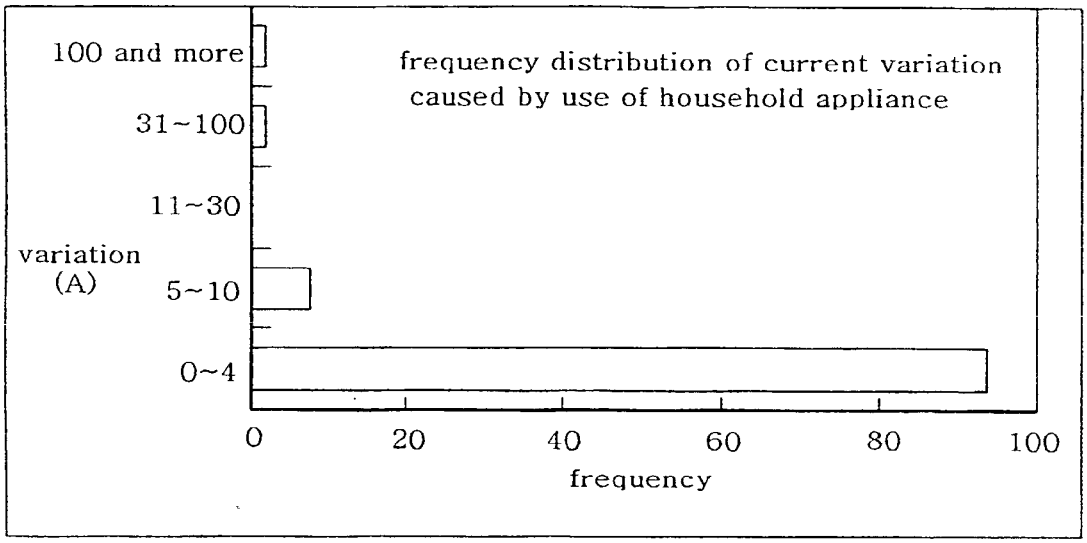

unit time A(i) divided into m parts
Ta(i, 1)
Ta(i, 2)
Ta(i, j-1)
Ta(i, j)
Ta(i, m)
t
IPT(i, 1)
⊿IPT(i, j)
IPT(i, j-1)
IPT(i, j)
IPT(i, m)

FIG. 6


frequency distribution of current variation
caused by use of household appliance
100 and more
31~100
11~30
5~10
0~4
variation
(A)
0
20
40
60
80
100
frequency

#4

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or the below named inventors believe they are the original, first and joint inventors (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled **A METHOD FOR DETECTING TRACKING SHORT**, the specification of which:

☐ is attached herewith.
☒ was filed on March 29, 2002 as Application Serial No. 10/089,591.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the Patent and Trademark Office all information known to me to be material to patentability of the subject matter claimed in this application, as "materiality" is defined in Title 37, Code of Federal Regulations, § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN APPLICATION(S)

			Priority Claimed
PCT/JP00/06669	Japan	September 27, 2000	Yes
(Number)	(Country)	(Date Filed)	
11/276207	Japan	September 29, 1999	Yes
(Number)	(Country)	(Date Filed)	

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose all information known to me to be material to the patentability of the subject matter claimed in this application, as "materiality" is defined in Title 37, Code of Federal Regulations, § 1.56, which become available between the filing date of the prior application and the national or PCT international filing date of this application:

N/A		
(Application Serial No.)	(Filing Date)	(Status)
N/A		
(Application Serial No.)	(Filing Date)	(Status)

I hereby claim the benefit under title 35, United States code §119(e) of any United States provisional application(s) listed below:

(Application Serial No.)	(Filing Date)
N/A	
N/A	

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each an attorney or agent of the firm of CONLEY, ROSE & TAYON, P.C., as its attorney or agent for so long as they remain with such firm, with full power of substitution and revocation, to prosecute the application, to make alterations and amendments therein, to transact all business in the Patent and Trademark Office in connection therewith, and to receive any Letters Patent, and for one year after issuance of such Letters Patent to file any request for a certificate of correction that may be deemed appropriate.

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I hereby declare that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

1-00

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